Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: CERTIFICATE IN ROCK MECHANICS **PAPER 3.3:** MASSIVE UNDERGROUND MINING (HARD AND SOFT ROCK)	**EXAMINER:** N MALITINO **MODERATOR:** J WALLS
SUBJECT CODE: COMRMC 3.3 **DATE 12 MAY 2022** **TIME**: **14H30 TO 17H30**	**TOTAL MARKS:** [100] **PASS MARK:** (60%)

NUMBER OF PAGES: 4

THIS IS NOT AN OPENBOOK EXAMINATION – ONLY REFERENCES PROVIDED ARE ALLOWED

SPECIAL REQUIREMENTS:

1. **Answer All the Questions**. Answer the questions **legibly** in English.
2. Write your **ID Number** on the outside cover of each book used and on any graph paper or other loose sheets handed in.

NB: Your name **must not** appear on any answer book or loose sheets.

3. Show all calculations **and check calculations on which the answers are based.**
4. Hand-held electronic calculators may be used for calculations. **Reference notes may not be programmed into calculators.**
5. Write **legibly** in ink on the **right-hand page** only – **left hand pages will not be marked**.
6. Illustrate your answers by means of sketches or diagrams wherever possible.
7. **Final answers** must be given to an accuracy which is typical of practical conditions, however, be careful not to use too few decimal places during your calculations, as rounding errors may result in incorrect answers.

NB: Ensure that the correct unit of measure (SI unit) is recorded as marks will be deducted from answers if the incorrect unit is used even if the calculated value is correct.

8. In answering the questions, full advantage should be taken of your practical experience as well as data given.
9. Please note that you are not allowed to contact your examiner or moderator regarding this examination.
10. Cell phones AND OTHER SMART DEVICES are **NOT** allowed in the examination room.

General

Where assumptions are required, the candidate is expected to clearly state the assumptions that govern the answer(s).

Total Mark = (100)

Question 1 **[25]**

1.1. List five reasons for carrying out geotechnical investigations. (5)

1.2. Describe a geotechnical investigation programme to determine the orebody and host rock properties for a mining project, and associated mining method. Describe the method that you will employ, the limitations thereof and how you would address the limitations of the programme. (10)

1.3. Name sources of seismicity typically present in massive mines (state the type of massive mining method(s) that you are referring to). (5)

1.4. Name tactics and strategies in which a massive mine can mitigate the risk of potentially damaging seismic events (state the type(s) of massive mining method(s) that you are referring to). (5)

Question 2 **[25]**

The footprint of a near vertical kimberlite orebody is approximately 80 m wide and 200 m long, open at depth. The kimberlite has a Mining Rock Mass Rating (MRMR) of about 40 and is hosted within granite, which has a MRMR of 55. The upper part of the orebody has been extracted by surface mining to a depth of 300 m. It is planned to extract the orebody to a depth of 500 m below surface by block caving.

2.1. Determine the cave angle and the extent of the zone of failure on surface. Use this information to determine how far the shaft should be positioned from the orebody. Illustrate by means of a sketch. Discuss limitations of this approach, and methods that you would employ to refine (improve) the confidence in design criteria for positioning the shaft and other infrastructure. (8)

2.2. If the undercut is mined across the full width of the orebody, determine how far the undercut needs to advance before caving is induced using Laubscher's method (include and annotate the relevant graph with your script). Discuss the limitations of this approach to determine accurate caving onset diameters, suitability of the rock mass for caving, and realistic undercut configurations that will be applied to induce caving. (8)

2.3. Due to high stress and the relatively low strength of the kimberlite, damage to draw bells and production level can be anticipated. Describe, with the aid of sketches, two methods to prevent this damage using the undercut (9)

Question 3 **[25]**

Your mine intends to use hydraulic backfill in open stopes (Blast Hole Stope / Long hole Stope), which were unfilled.

3.1. With the aid of a sketch discuss the application of backfill and what you would consider as important with reference to placement in an open stope, curing time as well as the importance of stand-up height. (5)

3.2. What tests would you conduct on the backfill and why? How can you improve the quality if the results are lower than the requirements? (5)

3.3. Briefly describe the key points to consider when designing a bulkhead. (4)

3.4. Using the given equations (below) calculate the required Uniaxial Compressive Strength (UCS) in kPa to fulfil the backfill freestanding stand-up heights (H) as shown in Table 1 below. Tabulate your results. Make use of the graph paper provided to illustrate your results (UCS vs stand-up height). Discuss the results. (11)

Dimensions of the open stope and characteristics of the backfill are:

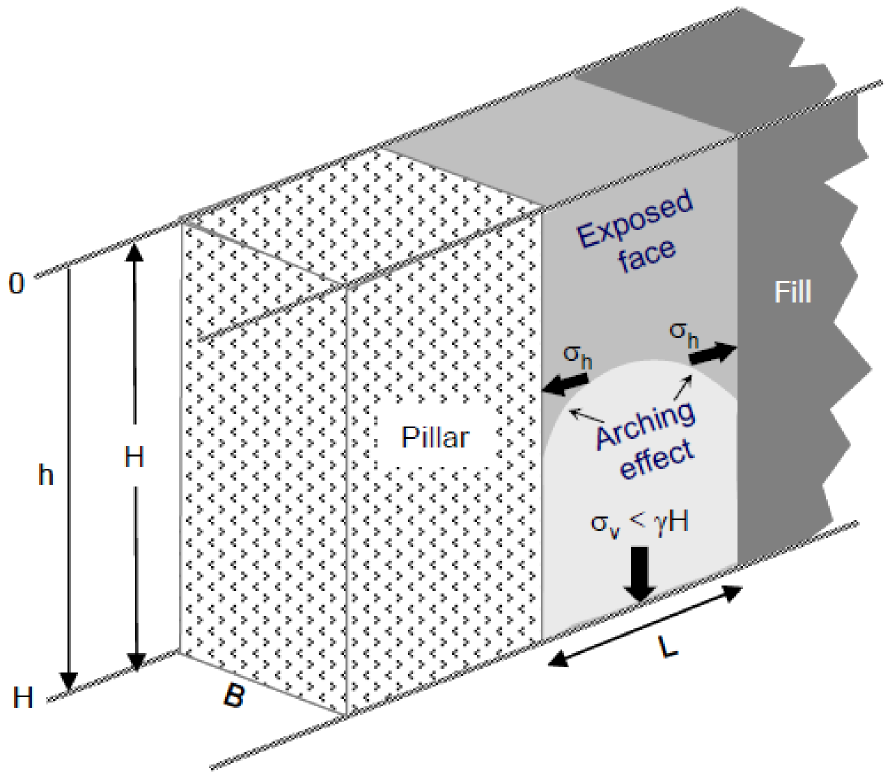
- Stope width (B) = 20 m
- Internal frication angle (ϕ) of the backfill = 25°
- Cohesive strength (c) of the backfill = 20 kPa
- Bulk unit weight (γ) of the backfill = 22 kN.m^{-3}
- Minimum required safety factor required = 1.5
- K = backfill pressure coefficient

Table 1: Required stand-up heights for backfilled open stopes

Height	5 m	10 m	15 m	20 m	30 m	40 m	50 m

$$UCS_{design} = \frac{1.25B}{2K\tan\phi}\left(\gamma - \frac{2c}{B}\right) \times \left[1 - \exp\left(-\frac{2HK\tan\phi}{B}\right)\right] FS$$

$$K = \frac{1+\sin^2\phi}{\cos^2\phi + 4\tan^2\phi} = \frac{1}{1+2\tan^2\phi}$$



Question 4 [25]

Questions 4.1. to 4.5: choose the correct answer, e.g. **4.1. (x)**.

4.1. The thickness of strata to be supported is 1.6 m. The density of the rock is assumed to be 2 900 kg.m^{-3}, and the gravitational acceleration is taken as 9.81 m.s^{-2}. The required support capacity for a FoS = 1.5 to support the above-mentioned strata is: (2)

a) 38.6 kN.m^{-2}

b) 50.4 kN.m^{-2}

c) 40.2 kN.m^{-2}

d) 45.5 kN.m^{-2}

4.2. A ‘45° rule’ is normally referred to: (2)

a) Avoid placing a drive (tunnel) in the low stressed abutment stress lobes created by a proximal excavation (heading)

b) Ensure that a drive (tunnel) is placed in the highly fractured abutment stress lobe created by a proximal excavation (heading)

c) Ensure that a tunnel (drive) will be placed in the highly stressed abutment stress lobe created by a proximal excavation (heading)

d) Ensure that a tunnel (drive) will not be placed in the highly stressed abutment stress lobe created by a proximal excavation (heading).

4.3. In very shallow Bord and Pillar mining (depths < ± 400mbs), in-stope pillars are required to: (2)

a) carry the full weight of overburden up to surface due to the absence of stress levels sufficient for assisting stability

b) carry the full length of overburden up to surface due to the stress levels sufficient for assisting stability

c) carry the full weight of overburden up to surface due to the presence of high stress levels sufficient for assisting stability

d) carry the full weight of overburden up to 20 m from surface due to the absence of stress levels sufficient for assisting stability.

4.4. Appropriate factor of safety applied to support design to ensure stability in a short- to medium-term excavation is typically in the order of: (2)

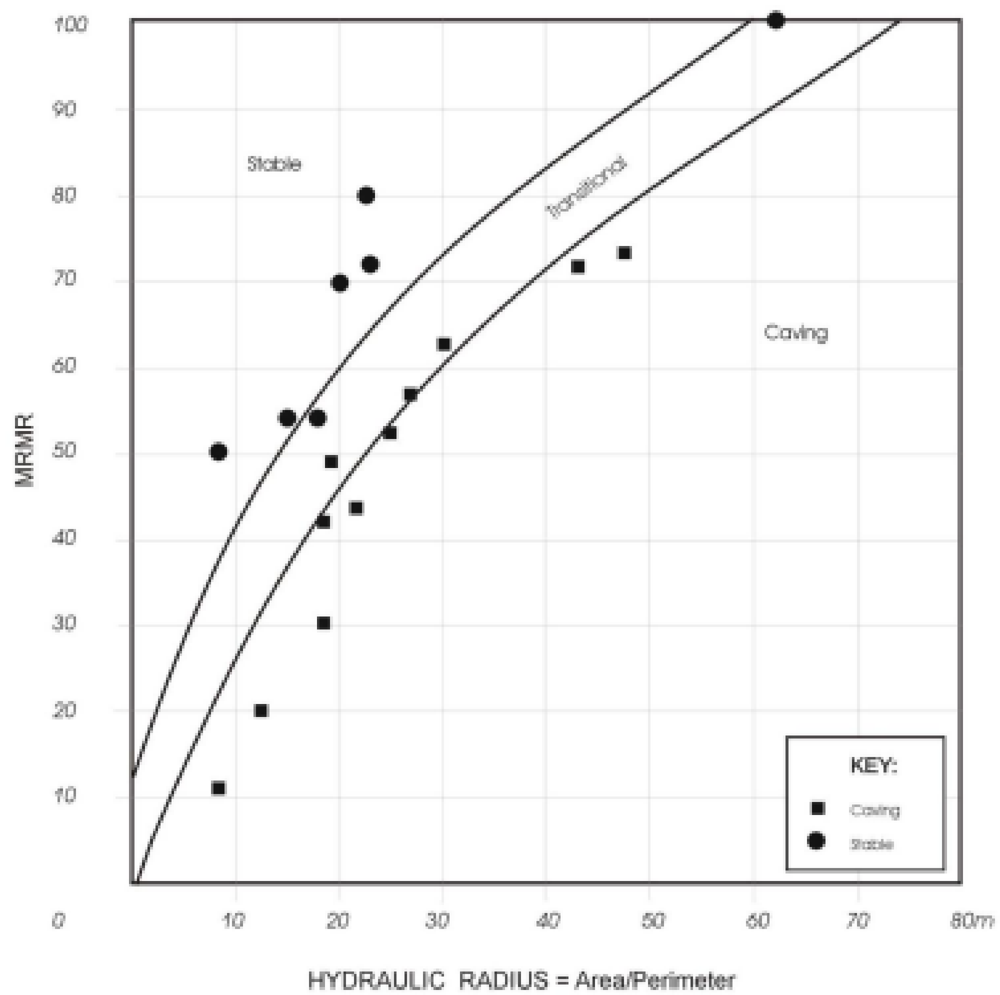
a) 1.2 to 1.5
b) 0.9 to 1.5
c) 1.5 to 2.0
d) > 2.0

4.5. In quasi-static conditions, shallower mines generally have: (2)

a) a higher fall out height compared to deeper mines.
b) a lower fall out height compared to deeper mines.
c) no difference in fall out height compared to deeper mines.
d) none of the above.

4.6. You are required to plan and execute an integrated instrumented monitoring plan for a massive mining operation, mining at 500 m or more below surface. Mining is expected to result in rock mass response that consists of gravitationally driven, stress driven and seismic effects. Discuss three monitoring systems, the instruments associated with each of the systems, communication and reporting requirements, trigger thresholds, placement of the instrumentation and management of the monitoring programme. (12)

4.7. List three principal components influencing the risk of a mud rush (mud push) from a drawpoint. (3)



Laubcher's Stability graph

Cave angle and failure zone (Laubscher 1990)

	Condition	Depth (m)	Adjusted *MRMR* 100-81	80-61	60-41	40-21	20-0
Cave angle	No lateral restraint	100	80	70	60	50	40
		500	70	60	50	40	30
	Lateral restraint from caved material	100	90	80	70	60	50
		500	80	70	60	50	40
Extent of failure zone	Surface	100	10 m	20 m	30 m	50 m	75 m
		500	10 m	20 m	30 m	50 m	75 m
	Underground	100	10 m	20 m	30 m	50 m	100 m
		500	20 m	30 m	50 m	100 m	200 m